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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/881,408	06/13/2001	Kie Y. Ahn	MI22-1534	8492

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EXAMINER

LE, THAO X

ART UNIT	PAPER NUMBER
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2814

DATE MAILED: 12/30/2002

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

09/881,408

Applicant(s)

AHN ET AL.

Examiner

Thao X Le

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 29 October 2002.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-31, 52 and 54-59 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☒ Claim(s) 56-59 is/are allowed.
- 6) ☒ Claim(s) 1-9, 13-27, 29-31, 52, 54 and 55 is/are rejected.
- 7) ☒ Claim(s) 10-12 and 28 is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
- Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on _____ is: a) ☐ approved b) ☐ disapproved by the Examiner.
- If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

- 13) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- * See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).
- a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 10.
- 4) ☐ Interview Summary (PTO-413) Paper No(s). _____.
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: _____.

DETAILED ACTION

Acknowledgement

1. Applicant's cancellation of claim 53 in Paper No. Is acknowledged.

Claim Rejections - 35 USC § 102

2. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

3. Claims 1-2, 6-7, 19-21, 25, 52-54 are rejected under 35 U.S.C. 102(e) as being anticipated by Pub. No.: U.S 2001/0013629 to Bai.

Regarding to claim 1, Bai discloses a method of forming a dielectric layer fig. 1 comprising: a substrate 105 comprising a silicon-containing surface, forming a first metal-containing dielectric layer 130 over the surface, the metal comprising of the first dielectric layer consisting of at least one element selected from group IVB of the periodic table [0018], forming a second metal-containing dielectric layer (a third dielectric layer), [0027], on the first metal-containing dielectric layer, the metal of the second dielectric layer consisting of at least one element selected from Group IIIB of the periodic table, [0027].

Regarding to claims 2, Bai teaches the first metal-containing dielectric layer 130 consists of hafnium, paragraph [0018].

Regarding to claims 6, 7, Bai teaches the second metal-containing dielectric layer comprises an element selected from group IIIB of the periodic table, where the second metal-containing dielectric layer comprises lanthanum, paragraph [0027]

Regarding to claims 19, 25 Bai teaches the first metal-containing dielectric layer consist of hafnium oxide and the second metal-containing dielectric layer (a third dielectric layer) consist of lanthanum oxide, paragraph [0018] and [0027].

Regarding to claim 20, Bai discloses a method of forming a MOS transistor in fig. 1 comprising: a substrate 105 comprising a silicon-containing surface, forming a hafnium-containing dielectric layer 130 over the surface, forming a lanthanum-containing dielectric layer (a third dielectric layer), [0027], on the hafnium-containing dielectric layer 130, and forming a gate electrode 110 over the hafnium-containing and lanthanum-containing dielectric layers.

Regarding to claim 21, Bai discloses the method wherein the lanthanum-containing dielectric layer is formed on the hafnium-containing dielectric layer, fig. 1.

Regarding to claim 52, Bai reference teaches a method of forming a dielectric layer comprising: providing a substrate 105 comprising a silicon-containing surface [0016], forming a first metal-containing dielectric layer 130 over the surface, the metal comprising an element selected from group IVB of the periodic table [0018], forming a second metal-containing dielectric layer (a third dielectric layer) on the first metal-containing dielectric layer, the second dielectric layer comprising an element selected from Group IIIB of the periodic table, [0027] fig. 1.

Regarding to claim 54, Bai reference teaches a method of forming a MOS transistor, comprising: providing a semiconductor substrate 105 having a surface comprising a silicon

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[0016], forming a dielectric layer 130 consisting of hafnium oxide overlying the surface, [0018], forming a dielectric layer (a third dielectric layer), [0027], consisting of lanthanum oxide on the hafnium oxide dielectric layer, and forming a gate electrode 110, [0016] over the hafnium oxide and lanthanum oxide dielectric layers, fig. 1

4. Claims 1, 6-8 are rejected under 35 U.S.C. 102(e) as being anticipated by Pub. No.: U.S. 2002/0145168 to Bojarczuk, Jr. et al.

Regarding to claim 1, Bojarczuk discloses a method of forming a dielectric layer fig. 1 comprising: a substrate 113 comprising a silicon-containing surface, forming a first metal-containing dielectric layer 111 over the surface, the metal comprising of the first dielectric layer consisting of at least one element selected from group IVB of the periodic table [0046], forming a second metal-containing dielectric layer (additional insulating layer), [0048], on the first metal-containing dielectric layer 111, the metal of the second dielectric layer consisting of at least one element selected from Group IIIB of the periodic table, [0048].

Regarding to claims 6-7, Bojarczuk discloses the method wherein the metal of the second metal-containing dielectric layer consists of one element selected from Group IIIB of the periodic table [0048], and wherein the metal of the second metal-containing dielectric layer consists of lanthanum, [0048].

Regarding to claim 8, Bojarczuk discloses the method wherein forming of the first metal-containing dielectric and the forming of the second metal-containing dielectric layer comprise: forming a hafnium-containing layer 111, [0046], forming a lanthanum-containing layer (an additional insulating layer), [0048], over the hafnium-containing layer, and exposing the hafnium-containing layer and lanthanum-containing layer to a oxygen comprising atmosphere,

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[0033] and heating the hafnium-containing layer and the lanthanum-containing layer to a temperature effective to form a hafnium-containing dielectric layer and a lanthanum-containing dielectric layer, [0033].

Claim Rejections - 35 USC § 103

5. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

6. Claims 3-5, 23 are rejected under 35 U.S.C. 103(a) as being unpatentable over US Pub. 2001/0013629 to Bai, and further in view of US Patent 6,184,072 to Kaushik et al.

Regarding to claim 3, 23 Bai does not expressly disclose the method further comprising: forming a silicon dioxide layer overlying at least one portion of the surface, and wherein forming the first metal-containing dielectric layer comprises forming a metal layer over the layer of silicon dioxide, and combining the metal layer with oxygen of the silicon dioxide layer to form a metal oxide dielectric material.

However, Kaushik reference discloses forming a silicon dioxide layer 14, fig. 1, column 2 line 30 and 60, overlying at least one portion of the surface, forming the a hafnium metal layer 16, fig. 2, column 2 line 47 and column 3 line 2, over the layer of the silicon dioxide; and combining metal layer with oxygen of the silicon dioxide layer to form a metal oxide dielectric material 18, fig. 3, column 3 line 13-30. At the time of the invention was made; it would have been obvious to one of ordinary skill in the art to

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combine the metal layer with oxygen of the silicon dioxide layer teaching of Kaushik with Bai method to form a first metal dielectric material, because it would have created a high-K dielectric layer as taught by Kaushik, column 3 line 28.

Regarding to claim 4, Bai discloses the first metal-containing dielectric layer 130 comprises hafnium, [0018].

Regarding to claim 5, Bai does not expressly disclose the combining comprises providing conditions effective to the hafnium of the metal layer to chemically reduce the silicon dioxide layer.

However, Kaushik reference discloses the combining comprises providing conditions effective to the hafnium of the metal layer to chemically reduce the silicon dioxide layer, column 3 lines 13-30. At the time of the invention was made; it would have been obvious to one of ordinary skill in the art to combine the chemically reduce the silicon dioxide layer by hafnium of Kaushik with Bai method, because it would have achieved an optimal increase in dielectric constant as taught by Kaushik, column 3 line 11.

7. Claims 8-9, 16-17, 24, 26, and 55 are rejected under 35 U.S.C. 103(a) as being unpatentable over US Pub. 2001/0013629 to Bai in view of US Patent 6,399,521 to Zhang et al.

Regarding to claims 8, 24, 26 as discussed in claim 1, the combination of Bai disclose all the limitations in claim 8, except Bai does not expressly disclose exposing the hafnium-containing layer and the lanthanum-containing layer to an oxygen comprising atmosphere and heating the hafnium-containing layer and the lanthanum-containing layer to a temperature

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effective to form a hafnium-containing dielectric layer and a lanthanum-containing dielectric layer.

However, Zhang reference discloses exposing the metal layer to an oxygen comprising atmosphere at the temperature from 400 column 6 lines 25-34. At the time of the invention was made; it would have been obvious to one of ordinary skill in the art to combine the exposing metal-containing layer to an oxygen comprising atmosphere teaching of Zhang with Bai, because it would have created a metal oxide layer as taught by Zhang, column 6 line.

Regarding to claims 9, 16-17, Bai discloses the gate dielectric is deposited by conventional techniques such as CVP or others, [0017]. In addition, Zhang discloses the CVP, PVD, & MOCVD processes to deposit hafnium-containing layer 14 fig. 3, column 5 line 51. At the time of the invention was made; it would have been obvious to one of ordinary skill in the art to select the deposition process as disclosed above, because such processes have been commonly used in the art.

Regarding to claim 55, Bai discloses a method for forming a MOS transistor, comprising: providing a semiconductor substrate 105 having a surface comprising a silicon [0016], forming a hafnium-containing layer 130 overlying the surface, forming a lanthanum-containing dielectric layer, (as third dielectric layer), [0027], overlying the hafnium-containing dielectric layer, and forming a gate electrode 110, [0016] over the hafnium-containing and lanthanum-containing dielectric layers, fig. 1

But Bai does not disclose the method comprising oxidizing the hafnium-containing layer into a hafnium-containing dielectric layer.

However, Zhang reference discloses oxidizing the hafnium-containing layer into a hafnium-containing dielectric layer, column 5 lines 57-62. At the time of the invention was made; it would have been obvious to one of ordinary skill in the art to use the annealing teaching of Zhang with Bai, because it would have oxidized the metal as taught by Zhang, column 5 line 61.

8. Claims 13-15, 18, 29-31 are rejected under 35 U.S.C. 103(a) as being unpatentable over US Pub. 2001/0013629 to Bai and US Patent 6,399,521 to Zhang et al. as applied to claims 1 and 8 above, and further in view of. US Patent 6,184,072 to Kaushik et al

Regarding to claims 13, 14, 29-31 Bai discloses forming the hafnium-containing dielectric layer 130 (t_1) less than or equal to about 5 nanometer (nm), see table 1, and forming the lanthanum-containing dielectric layer (third dielectric layer), [0027], with various thickness ratio of t , t_1 and t_2 , table 1.

But Bai does not expressly disclose depositing the lanthanum to the thickness less than or equal to 5 nm, and a ratio of the hafnium thickness to the lanthanum thickness of about 1 to 3 to about 1 to 4.

However, Kaushik reference discloses forming a metal layer to a thickness less than or equal to about 5 nm, column 3 line 7. At the time of the invention was made; it would have been obvious to one of ordinary skill in the art to combine the metal thickness teaching of Kaushik with Bai method, because such thickness or particular metal will depend upon dielectric constant desired as taught by Kaushik, column 3 line 5.

Regarding to claims 15, 18, Bai's reference does not disclose forming the metal containing dielectric layer and the second metal-containing dielectric layer comprises forming the layer to have respective thickness having a ratio of from about 4:1 to about 1:4.

However, Bai's reference teach different thickness ratio between first and second metal-containing dielectric layer, paragraph [0020-0024] and table 1. Accordingly, it would have been obvious to use the teaching ratio of Bai's method in the range as claimed, because it has been held that where the general conditions of the claims are disclosed in the prior art, it is inventive to discover the optimum or workable range by routine experimentation. See *In re Aller*, 220 F.2d 454, 105 USPQ 233, 235 (CCPA 1955).

Allowable Subject Matter

9. Claims 10-12, and 28 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

- With respect to claim 10, the prior art of record fails to disclose all the limitation in claim 10, including the exposing comprises ion bombardment of the hafnium layer and the lanthanum-containing layer using and ion bombardment energy of about 10 EV or less.
- With respect to claim 11, the prior art of record fails to disclose all the limitation in claim 11, including the heating comprises heating the temperature from about 200°C to about 400°C during the ion bombardment.

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- With respect to claim 12, the prior art of record fails to disclose all the limitation in claim 12, including the exposing to oxygen radicals.
- With respect to claim 28, the prior art fails to disclose all the limitations in claim 28, including providing ion bombardment of the hafnium layer and the lanthanum-containing layer using and ion bombardment energy of about 10 EV or less and where the heating to an effective temperature comprises heating while providing ion bombardment to a temperature from about

10. Claims 56-59 are allowed.

- With respect to claim 56, the prior art fails to disclose all the limitations of the base claim 56 including exposing the hafnium-containing layer and the lanthanum-containing layer to an oxygen comprising atmosphere by ion bombardment using an energy of about 10 eV or less.
- With respect to claim 58, the prior art fails to disclose all the limitations of the base claim 58 including positing the substrate within a reaction chamber and exposing the hafnium-containing and lanthanum-containing layer to oxygen radicals with the reaction chamber and heating the hafnium-containing and lanthanum-containing layer to a temperature effective to form a hafnium-containing dielectric layer and lanthanum-containing dielectric layer.

Response to Arguments

11. Applicant's arguments filed 10/29/02 have been fully considered but they are not persuasive. The Applicant argues that the prior art (Bai) does not disclose or suggest the third

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dielectric layer on bottom dielectric layer 130. This is not persuasive because claim in a pending application should be given their broadest reasonable interpretation. In re Pearson, 494F.2d 1399, 181 USPQ 641 (CCPA 1974). In this case, Bai discloses the third dielectric layer [0027] on the bottom dielectric layer 130. The terms 'on' and 'over' would be interpreted in the same way, because they do not necessarily imply a directly in contact. Therefore, Bai's third dielectric meets the claim language.

Conclusion

Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire **THREE MONTHS** from the mailing date of this action. In the event a first reply is filed within **TWO MONTHS** of the mailing date of this final action and the advisory action is not mailed until after the end of the **THREE-MONTH** shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than **SIX MONTHS** from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Thao X Le whose telephone number is 703-306-0208. The examiner can normally be reached on M-F from 8:00 AM - 4:30 PM.

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If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Wael M Fahmy can be reached on 703-308-4918. The fax phone numbers for the organization where this application or proceeding is assigned are 703-308-7722 for regular communications and 703-308-7722 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0956.

Thao X. Le
December 24, 2002



PHAT X. CAO
PRIMARY EXAMINER